ONTARIO
DEPARTMENT OF
EDUCATION

General and Advanced Levels of Instruction in Grade 13

Biology

JANUARY, 1966

As recommended by the General and Advanced Committee which conducted part of the Grade 13 studies, the suggested outlines listed below have been prepared at the direction of the Minister of Education by the Curriculum Division with the assistance of university and secondary school personnel. The outlines are to be considered as working papers rather than definitive courses. It is expected that they would be subject to further development and change if it is decided to submit them to field testing. They are being distributed to the universities and to the secondary schools for evaluation.

GA. 31 Accountancy and Secretarial

GA. 13 Art

GA. 17B Biology

GA. 11 Classics

GA. 18 Chemistry

GA. 4 English

GA. 46 français

GA. 15A French

GA. 17E General Science

GA. 7 Geography

GA. 15B German

GA. 9 History

GA. 12 Mathematics

GA. 16 Music

GA. 17C Physics

BROAD SUGGESTED OUTLINES OF PROPOSED GENERAL AND ADVANCED COURSES IN BIOLOGY

The committee has presumed that the Advanced Level course will be taken by students with a special interest in biology, many of whom may wish to go on to post-secondary school courses involving some form of biology.

The formal background of students entering either the Advanced or General Level course will, however, be the same, so that both courses must cover the same general principles. In order to match the greater intensity of interest the Advanced Level student would be expected to bring to his work, the Committee felt that the Advanced course should not merely be an extension of the General course, but a separate course aimed more accurately at its potential clientele.

The ecological approach, because it allows the maximum extension of topics likely to be of the greatest importance to the intelligent layman of the future, was judged most appropriate to the general course. It is not necessarily the best approach for the person of greater depth of interest or for the person who may require biological information in his later professional life. The Advanced course candidate is likely already aware of, or can easily be made aware of, many of the points that it would be the main burden of the General course to establish. An extension of the material of the General course to the advanced level might, therefore, only have the effect of increasing the amount of detail the student becomes responsible for, without necessarily offering him a greater conceptual challenge.

Of the many possible approaches, the committee has decided that one with a strong evolutionary and phylogenetic theme would be the most appropriate to the Advanced Level.

The theory of evolution is one of the great unifying concepts in biology, to which virtually every branch of the subject, classical and modern, has contributed in some degree. Within the evolutionary approach it is possible to deal with every important general principle, to expose the student to a great variety of different organisms, to survey the subject within the dimensions of both space and time, and to do all this within a logical and coherent framework.

GENERAL LEVEL COURSE

The course proposed here sets out to teach the basic principles of biology, using ecology as the main theme and chief means of approach. It is felt that this course can be successfully mounted in the time of three hours per week (or perhaps three double 35-minute periods per week). The week-by-week allotment of the time to laboratory and lesson work is left to the discretion of the teacher. It could well vary from topic to topic. At least one-third of the time should be devoted to some type of experimental work.

Considerable flexibility has been built into the course, and it is to be hoped that teachers will take advantage of this feature to exercise their special talents and interests, the better to excite, enlarge, and deepen their students' insights. At the same time, it is recognized that some teachers will feel the need of specific guidance as to the detail that could be included under one given topic or another. Accordingly, it is suggested that each main part of the course be given a minimum time allowance of twelve hours. There remains approximately twenty hours which teachers are free to apply to those topics which their interests, or the interests of the students, dictate.

These basic attitudes underlie the course:

1 The living world is characterized by interdependence. Man is an integral part of the complex of organisms, and the major influence in living communities.

2 The major problems facing present and future generations are basically biological and may involve ecological principles. The population explosion, environmental pollution, the application of the new knowledge from genetics, and a host of similar problems requiring political and social solution can be resolved only by citizens having an understanding of basic biological principles.

3 The study of a science such as biology develops an understanding of the nature and use of scientific method. In a world so generally influenced by science, everyone should have an understanding of the scientific enterprise.

4 Science progresses by experiment, observation, critical thinking, and informed speculation. It is therefore proposed that teachers and students be encouraged to explore the themes to be developed as much as possible through experiments, field work, reading, writing essays, and discussion.

The course has been arranged, for convenience, in five parts. There is sometimes a tendency for teachers and students to feel that each part or unit of a course is complete within itself, and that it ought to stand as an isolated segment of work quite without dependence or connection with the other parts. This course is intended to be unified into a comprehensible whole by the continual development of the inter-relatedness of its parts.

The external examinations of the past have had a strong influence both on the specific matter dealt with in the classroom and on the manner of presentation. The course is not intended to be a list of specific topics and experiments for examination purposes. The object has been, in part, to free teachers and students from a rigid and stereotyped curriculum. For example, there is available a multiplicity of laboratory exercises for studying osmosis, dialysis, plasmolysis, and turgor. It is hoped that teachers will use those procedures that suit them best, and that some students may try other methods in their own time. Then the examination questions will have to be framed to test the students' grasp of the concepts rather than his recollection of an arbitrary set of facts.

An increasingly rich supply of books, pamphlets, manuals, films, slides, and film-strips is available, as are inexpensive and convenient devices for culturing and maintaining a variety of organisms. The success of this course will depend to some extent on the use made of these resources, as well as on the more conventional teaching methods.

Divisions of the Course

Unit I ECOLOGICAL RELATIONSHIPS

1 The web of life
2 The constitution of populations
3 Communities and ecosystems

Unit II TAXONOMIC RELATIONSHIPS

1 The nature of the classification system and the need for such a system
2 Protists
3 Animals
4 Plants

} A broad survey to illustrate diversity of form and habitat

Unit III DISTRIBUTIVE RELATIONSHIPS

1 Distribution of micro-organisms
   (a) the soil ecosystem
   (b) the micro-biota of organisms
2 Life on land
3 Life in water
4 The geography of life

Unit IV INTERNAL RELATIONSHIPS

1 The cell
2 The functioning plant
3 The functioning animal

Unit V ADAPTIVE RELATIONSHIPS

1 The phenomenon of reproduction
2 Heredity
3 Long term genetic adaptation (evolution)
4 Short term adaptation (behaviour or growth)

ADVANCED LEVEL COURSE

It is proposed that in general outline the Advanced course be built around an exploratory ascent of the phylogenetic tree, tracing out, in terms of the likely evolutionary history of organisms, the outlines of its main branches; illustrating each main division with as wide a variety of organisms as can be gathered into the

classroom: plant and animal, macroscopic and microscopic, living and fossil.

In the course of this ascent, organisms will be encountered which illustrate in a very clear and straightforward way important biological principles of biochemistry, of physiology, of morphology, of development, of taxonomy, and of ecology. The choice of organisms would be dictated not only by the significance of their phylogenetic position, but by the aptness with which they can be used to illustrate important principles.

Although the student would become familiar in a general way with the structure and life of each of the organisms examined, not all would be studied exhaustively from every point of view. Some might illustrate significant anatomical adaptations to a new mode of life; others might illustrate some important innovation in metabolism; others would be of greatest interest from the taxonomic or behavioural point of view; and it would be from these points of view that their study would be largely approached.

In preparing a detailed course based on this approach, the only difficulty is in choosing from the wealth of material that presents itself. For every point requiring illustration, a thousand examples can be chosen. It therefore seemed unnecessary to restrict the classroom teacher to a particular set of examples. It was, in fact, the Committee's opinion that many positive advantages would follow from allowing the individual teacher the greatest possible freedom in choosing his material from those areas where his own interest and that of his student's would tend to lead him. Not the least of these would be the impossibility of imposing on the advanced course the fact-repetition type of examination which has been so much the curse of biology in the past.

Accordingly, the course outline that follows indicates only the general divisions of the course and the general nature of the themes that might be pursued in each section. There are ten divisions to the course, and on the assumption that approximately one hundred and sixty hours would be available to an Advanced Level course, an equitable division of time would allow sixteen hours to each section. Although we wish to allow maximum flexibility, it is the Committee's opinion that none of these divisions should be completely omitted. It is therefore suggested that a minimum of eight hours be required in each division, the remaining time to be alloted at the discretion of the teacher.

It is absolutely essential in any biology course that the student acquire a first-hand as opposed to a textbook knowledge of the organisms studied. We therefore recommend that a considerable part of the assigned time should be spent in the laboratory in appropriate experimental and observational exercises. Although we hesitate to fix a rigid proportion between lesson and laboratory time, we suggest that at least thirty percent of the time be devoted to the laboratory.

It is assumed that each subject of the matriculation year could claim a just proportion of the student's unallotted time. It would not be unreasonable to expect that some of this time be spent in the laboratory on open-ended projects that would be pursued independently by the student with the advice and guidance of his teacher.

The preparation and supervision of laboratory periods would make heavy demands on the teacher's time. The Committee suggests that there would be little point in a school's offering Advanced Level Biology, assuming the physical resources were adequate, unless considerably more teacher-time could be allotted to it than that required for scheduled instruction of classes. It should also be obvious that a prerequisite to offering Advanced Level Biology would be the ability of the principal to schedule two- to three-hour periods for laboratory work.

The emphasis on laboratory work is dictated by the committee's conviction that the general aims of the matriculation year could best be met in Biology by making the laboratory the chief means of instruction, together with appropriate background reading and

follow-up assignments. It is suggested that the shorter non-laboratory periods be devoted to a discussion of points arising from the laboratory work and follow-up assignments. Only in the case of some particularly difficult or complex topic should the class time be used for formal lectures or conventional Socratic lessons.

It is also urged that an important vehicle of instruction be the preparation of formal essays in which the student is required to show that he has delved deeply into some biological topic arising from the course. There is no better aid to the development of lucid expression than to require the student to explain clearly and simply some complex and involved phenomenon.

The motive of the Committee in making many of the preceeding suggestions has been its awareness that it is not a printed outline of topics that makes a course interesting and valuable, but the spirit in which it is presented to the students taking it. No matter how intrinsically interesting or important the topics covered are, there will be very little benefit if they are presented as pieces of information to be copied down, memorized, and eventually repeated. Only if the topics are used as vehicles to exercise the initiative, rationality, judgment, and communicative skills of the student, will their full value be realized.

Divisions of the Course

Unit I INTRODUCTION

A *survey* of the structure, physiology, habitat, life cycle, general natural history, and taxonomic position of four key organisms: the dogfish shark, a native conifer, a polychaete worm (Nereis), and a moss, the whole program concluding in a discussion of the attributes of living things.

The object of this unit is to provide a frame of reference within which the student will find some orientation, while considering the wide variety of forms that will follow. It will also allow a review and reorganization of knowledge already gained. The types are chosen so as to be largely unfamiliar, and yet closely enough related to previously studied forms to aid in recalling knowledge of them.

Unit II PROTOEVOLUTION

Consideration of theories of the origin of the earth and reactions in the primeval atmosphere and oceans leading to the abiogenic origin of organic substances and the biologically significant substances; the organization of these materials into the first cells, and the energy sources of these cells.

This unit is the systematic commencement of the course. It is designed to emphasize the evolutionary bias of the course by a consideration of the changes in matter leading to conditions propitious to the emergence of life. Opportunity can be taken here to emphasize the fact that all disciplines have a meeting ground in the subject matter of biology, and to emphasize the role played by men like Urey and Oparin, who, by bringing together knowledge from all branches of science, succeed in generating significant new ideas and advances.

Unit III THE MONERA

The bacterial cell; its reproduction, genetics and respiration, heterotrophic and autotrophic; the blue-green algae; and the general role of photosynthesis; the viruses and their nature.

Within this unit some basic ideas regarding cellular physiology, biochemistry, genetics, and selection can be introduced, while at the same time the organisms which constitute one of the main trunks of the phylogenetic tree are explored.

Unit IV THE ALGAE

The structure of the algal cell; the chloroplast; photophosphorylations; the formation of organic substances from inorganic; the divergent evolution of photosynthetic and good storage systems within the algae; the emergence of sexuality and the various life cycle patterns; cellular movement and algal taxonomy.

This unit provides an opportunity for considering the perfection of the cellular organelles and the photosynthetic way of life, the role of sexuality in genetics and evolution, and the idea of evolutionary diversification along biochemical as well as morphological lines. Again, while doing this, the student can be made familiar with the organisms constituting a second of the main phylogenetic trunks.

Unit V THE FUNGI AND SLIME MOLDS

Neurospora and its genetics; yeast and the perfection of cellular respiration; its spatial organization within the mitochondrion; the structure and life cycles of puffball, Saprolegnia, Puccinia and Microsporum; parasitism and host specificity; the Myxomycophyta and the physical properties of protoplasm; fungal taxonomy.

Here, while becoming familiar with examples of each of the main types of fungi, the work on genetics and respiration can be intensified with organisms admirably suited to the purpose. The implications of the heterotrophic way of life can be pursued, and the pathway into parasitism, with the evolution of a high degree of physical and biochemical adaptation between host and parasite, can be discussed.

Unit VI THE LOWER INVERTEBRATES

Chaos chaos and amoeboid movement; the nature of the plasma membrane and movement across it; the parallel evolution of parasitism within heterotrophic organisms, Entamoeba, Plasmodium, Trypanosoma, Paramoecium and the cilium; general nature of irritability; colonial protozoans; sponges and simple cellular differentiation; the main types of coelenterates, their embryology, structure and modes of life, the taxonomy of the forms examined.

The purpose here is to become familiar with the organisms in the base of the animal trunk of the phylogenetic tree. The idea of parallel evolution can be introduced, noting affinities between the forms studied and the algae and fungi, as well as the idea of the evolutionary advantage of cellular differentiation and the efficiency of the division of labour it fosters.

Unit VII THE EMBRYOPHYTA

The Bryophytes, their structure and life; the tracheophytes and the emergence of special conducting tissues; the evolution of the vascular systems illustrated by comparative studies of primitive and fossil as well as extant groups of vascular plants; the evolution of the leaf as a photosynthetic organ and of the flower from it; the conquest of land by plants; the evolution of the pollen grain and seed habit; the great proliferation of the primitive tracheophytes in the carboniferous and of the advanced tracheophytes in the present; the parallel diversification of the dicotyledonous and monocotyledonous plants; comparative studies of pollination and fertilization and the adaptation of flower to pollinating agent; the growth of roots and stems and auxinal control by the stem apex.

This unit follows the theme of the conquest of the land by plants by exploring the evolution of a progressively more complex plant body, vascular system, photosynthetic organ, and floral organ. In the process the student will become familiar with many extant and fossil forms, and can be brought to realize the radiative nature of evolution, leading in every age to the creation of forms adapted to every feasible way of life.

Unit VIII THE HIGHER VERTEBRATES

The emergence of bilateral symmetry and the segmental body plan; cephalization and the elaboration of nervous control; the circulatory system and the maintenance of a constant internal cellular environment; embryological development of the mesoderm and coelom; the secondary suppression of the coelom in the acoelomate phyla, and of segmentation in the molluscs; degeneration of free-living forms to parasitism in the roundworms and flatworms, and to a sessile mode of life in the Cirripedia; Peripatus and the affinities of the Arthropods and Insects; radiation among the insects; the insect as a flying machine; the problem of the affinities of such

forms as the trilobites and Limulus; the Echinoderms, starfish and crinoids; phyletic evolution illustrated by forms like Micraster; the problem of chordate ancestry; taxonomy of the forms studied.

This unit is one of exceptional richness, and illustrative examples of virtually every biological theme are found here. Once again the theme of evolutionary radiation into every mode of life can be easily demonstrated, and the student can be invited to speculate on the inter-relations of the various groups as revealed by their morphological relations.

Unit IX THE CHORDATES

The chordate features and their embryological development as illustrated by some simple free-living form like Amphioxus; the enclosure of the spinal cord and brain as in the Agnathans; the evolution of the jaw; radiation in the water; the Cartilaginous fishes and bony fishes; Actinopterygians, Crossopterygians, the Dipnoi; the emergence of land forms like Stegocephalus; the development of modern amphibians; the hormonal control of metamorphosis; the reptiles and complete emancipation from the land; the development of the cornified skin, amniotic egg, and organs for internal fertilization; the rotation of the limbs, as illustrated by reptilian forms; the great radiation of the reptiles to all forms of life; the evolution of birds and mammals from reptilian forms; the emergence of courtship and sociality as illustrated by birds and mammals; the various mammalian orders; the evolution of the Primates; the origin of man; chordate taxonomy.

Once again there is a great wealth of material to choose from, but the general theme of the conquest of the land with the necessary morphological and behavioural changes, leading into the idea of the selection of intelligence as a means of survival, can be used to cement the topics in this unit together.

Unit X THE MECHANISM OF EVOLUTION

A discussion of evolutionary theories; random nature of mutation; natural selection; speciation; the mechanism of genetic isolation; evidences of evolution from plant and animal distribution; morphology; the fossil record, etc.; a summary of the interrelationships of the forms studied; the phylogenetic tree.

This unit is essentially a final summary and a delineation of what until now has been implicit. Opportunity can be taken here of re-introducing genetic concepts first encountered early in the course, and of showing how these contribute to evolutionary theory.

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